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INVENTORY OF FOREST AND RANGELAND AND DETECTION OF FOREST STRESS

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16. Abstract Lack of coverage by ERTS 1 over our study sites has prevented our determining the value of satellite imagery for forest and range inventory work. One fairly good image (1084-15440, Oct. 15, 1972) was received over the Atlanta, Georgia, site. Both system-corrected and scene-corrected CCT's were ordered and received after Jan. 1, 1973. The scene-corrected color composites have not been received. Only two bands of one ERTS image were received for part of our Manitou, Colorado, range site. One good ERTS image (1047-17175, Sept. 8, 1972) has been received over a small portion of the Black Hills site. One additional image, free of clouds (1100-17124, Oct. 31, 1972) completely covered the Black Hills site, but vegetation differences were obliterated by snow. Early indications are that detection of bark beetle infestations on ERTS imagery will be very difficult because of the low contrast ratios between dying (yellow to yellow-red) and healthy (green to green-yellow) trees.

Aerial imagery obtained by NASA aircraft (Missions 205, 211, 213, and 214) and Forest Service aircraft have been used to establish the training and test set locations (UTM's) of the various forest and range signatures.

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Figure 2. Technical Report Standard Title Page

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Atlanta Test Site (Forest Inventory) 226B

Coinvestigator: Robert C. Aldrich

GSFC Identification Number AG-014

Principal Investigator: Robert C. Heller

STATEMENT OF PROBLEMS:

1. Progress during the first six months of this study was limited by a number of problems, not the least of which was a lack of technician and computer programming support. This lack of support was generally the fault of inadequate Forest Service funding. One computer programmer called for in our proposal was not hired, and we have not filled one technician vacancy that opened up in July 1972. Although the funds are now available for a computer programmer, the current freeze on Federal hiring will delay filling this position indefinitely.

2. We have now received all interpretation and mapping equipment placed on order since March 1972. However, the delivery of a Bausch and Lomb Zoom Transfer Scope was only completed in December. Necessary tests, modifications, and accessories required to place this instrument in service for the interpretation and mapping portions of this study have not been completed.

3. Other equipment problems have been encountered. One of these involved the testing and calibration of an I^2S four-channel additive color viewer. Another was to develop a copying system for the image combiner so that 70 mm multispectral bulk film products could be combined and photographed for use in magnifying projectors for data analysis. Although we are making progress in these two areas, we are not satisfied with the results.

4. Our greatest problem has been in obtaining suitable ERTS data. Although some data were received for the Atlanta site in October, they covered only small portions of the site, and the cloud cover was more than was desirable. One acceptable set of MSS bulk data collected by ERTS on October 15 (scene number 1084-15440) was received on November 8, 1972. These data covered approximately the eastern two-thirds of the test site. Both bulk and precision film and tape products were ordered immediately. Only the tape data were received at the time of this report.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

Preparations and Equipment Developments:

1. Using 1:60,000 scale color infrared (CIR) photographs from the Earth Resources Aircraft Program (ERAP) Mission 191, 11,000 systematically located points were classified into eight land use classes and six resolution cell sizes. One hundred of these points (over 100 meters square) were selected from each land use class to serve in our data analysis. Of these, 50 were randomly selected as training sets for both photo interpretation and for computer classification procedures. The remaining 50 points will be used to test interpreters and various computer classification procedures.

The 800 points (eight classes x 100) were transferred to base maps using a combination of photographic and photogrammetric techniques. The base maps were made on stable base material at a scale of 1:83,000 and show 10,000-meter easterly and 10,000-meter northerly UTM coordinate intersections as well as 15-minute latitude and longitude tick marks. The base maps with 800 numbered point locations were photographed with a precision camera. The copy negatives were used to produce transparent overlays at a 1:1,000,000 scale for use on an I^2S image combiner. They will also be used to produce overlays at a 1:250,000 scale for use on an enlarging projector-viewer.

2. A portable photometer was developed to help calibrate the illumination levels of four channels on an I^2S image combiner. Not only is this necessary for calibration of the instrument, but it is also useful for measuring the individual channel light levels used in ERTS image enhancement.

3. Once the ERTS multispectral scanner data are properly enhanced on the I^2S viewer, it is necessary to copy the enhancement for use in interpretation devices as well as for illustrating results. This necessitated building a camera mount for a Speed Graphic Camera equipped with a 75 mm focal length lens. When completed, the mount and camera will be easily installed and calibrated with the I^2S viewer surface.

Aircraft and Ground Support:

1. Two RB-57 aircraft support missions were flown by the Manned Spacecraft Center. The first was flown on June 1, 1972, (Mission 205). The second was flown on October 2, 1972, (Mission 214).

2. Data from Mission 205 were not received by the investigator until September 17. Since then, the data have been reviewed, annotated, and the 800 forest and nonforest points were transferred from ERAP Mission 191 photography to the new photographs. These photographs were subsequently used on a ground check in October.

3. Mission 214 data were received on November 1. These data are being used to check the classifications on 800 observation points in preparation for analyzing ERTS scene 1084-15440 acquired only 13 days later.

4. Two field trips were made during the six-month period--June 21 to June 28 and October 6 to October 11, 1972. These two trips were made in connection with the two aircraft missions. One hundred and twenty points (20 from each of the forest and agriculture land use classes) were selected at random from the 400-point training set. A minimum of 15 of these points have now been verified in each class on the ground and pertinent data recorded for future use.

Film Data Analysis (Photo Interpretation):

1. Analysis of ERTS data has been limited by the few successful data collections over the site. Only two scenes were considered adequate for analysis using bulk MSS data. Only one of these was considered worthy of a retrospective order for precision data.

2. Scene 1048-15434X taken on September 9, 1972, was analyzed on the I^2S image combiner. This analysis was described in Type I Progress Report - Number 2, dated November 8, 1972. In review, the resolution and spectral characteristics of this scene were found inferior to Apollo 9 (SO-65) CIR for the same area. Discrimination between individual forest classes and nonforest classes was impossible. When a CIR comparable enhancement was made on an I^2S additive color viewer, all agricultural land including crops, pasture, and idle land was a light grayish-pink. Forest land, on the other hand, was all red. It seems highly unlikely that summer imagery will ever be useful for forest inventory because infrared reflectance from all vegetation is so great that distinguishable contrasts between major vegetation types is lacking.

3. On November 8, 1972, ERTS 1 MSS bulk film products were received for scene 1084-15440X. This scene was obtained on October 15, 1972, and included Atlanta, Macon, and Columbus, Georgia. A portion of the forest inventory test site west and south of Atlanta was covered and included nine of ten 6.4- x 6.4-kilometer (4- x 4-mile) study blocks used in the ERAP. Although this scene does not cover the western portion of the test site, the high quality of these data and lack of previous data suggested that an analysis should be made. A retrospective order was placed for both bulk and precision data products to fulfill the requirements of our data analysis plan. Unfortunately, these data had not been received at the time of this report. However, we did make a preliminary analysis of bulk 70 mm film products.

Bulk 70 mm film chips for MSS channels 4, 5, 6, and 7 were combined on the I^{2}S viewer. Color enhanced images were photographed using tungsten type high-speed Ektachrome color transparency film (ASA 125). A Speed Graphic with a 75 mm focal length lens and a 120 roll film back were used to take the pictures. The camera was fixed in a special mount and adjusted to obtain a geometrically correct and scaled image on the film plane. This procedure introduced several problems which needed to be resolved. First, the type of viewing screen and the adjustment of lamps within the I^{2}S projector housing affected illumination fall off on the viewer screen. By centering the lamps in the viewer housing using a photometer and by substituting a screen with better diffusing properties, but reduced light transmittance (Polacoat Lenscreen Type OC 50), we were able to considerably improve the final image quality. At the same time, the reduction in transmittance did not noticeably affect the photographic exposure.

Several combinations of filters were used in the I^{2}S viewer to explore the enhancement of land use and forest conditions within areas of known ground truth. These combinations included the following:

Filter Combination	ERTS Channel			
	4	5	6	7
	I^{2}S filter			
1	blue	green	---	red
2	blue	green	red	red
3	blue	red	---	green
4	blue	red	green	green
5	green	red	blue	blue

Images on the viewer screen were photographed in a darkened room. First a Weston light meter reading was taken at the imaging screen. Generally speaking there was very little variation in light within the scene, but since we were most concerned with forest, we tried to read the light meter over the densest forest area. This turned out to be a value of 5 which converted to an exposure of f 11 for one second at ASA 125. A normal exposure and 1/2-stop underexposure were made for each enhancement.

The transparencies were mounted in 8.26- x 10.16-cm (3 1/4- x 4-inch) glass lantern slides. Each slide was then enlarged 20 times in a projection-viewer (see PUBLICATIONS) and evaluated for its filter enhancement qualities, exposure, and resolution.

The best exposure in every case was the normal exposure. The best filter enhancement combinations were 1 and 3. Because combination 1 looks so much like CIR film, we will call it simulated CIR and, similarly, because combination 3 makes vegetation look natural green, we will call it simulated normal color (NC). All combinations using both IR channels (channel 6 and channel 7) resulted in oversaturation of the scene in either red or green. Thus, channel 6 seems to have little value in this image analysis unless a fourth filter color can be added to the I^2S filter wheel. This possibility will be investigated.

The resolution qualities of ERTS data were best measured using farm ponds, roads, and wood lots as references. For instance, the smallest pond that could be separated from its surroundings measured 100 meters in the shortest dimension. Roads, on the other hand, were more difficult because of a lower contrast ratio with surrounding nonforest land. For this reason in those areas of known ground truth, no roads were visible. By comparison roads as narrow as 20 meters were visible on Apollo 9 imagery of these same areas. The only roads and power lines that can be detected on this ERTS scene have right-of-ways ranging from 75 to 100 meters wide.

The informational content of ERTS bulk data obtained in mid-October is rather restricted. Careful examination of combined three-channel (4, 5, 7) data on an enlarging viewer (20X) shows that most forest land can be separated from nonforest land. However, the smallest patch of pine type that can be detected within a hardwood stand, or the smallest patch of hardwood that can be detected within a pine stand, is not very small. These areas will be at least two acres under the best conditions and five acres under less than the best conditions. Individual fields cannot be separated at this time of year unless the field is a winter cover crop or a lush improved pasture. Although there seems to be little difference otherwise, the simulated true color enhancement (combination 3) shows the greatest discrimination between vegetation types, bare soil, and harvested crops (dead humus material). The bare soil appears orange-brown, and the old harvested fields and urban areas are brown. Detection of timber cutting areas is made easiest on the simulated true color; light brown caused by site scarification, roads, and scattered dead materials shows through the forest which appears green.

One interesting advantage that the simulated CIR (combination 1) had over the other filter combinations was to detect areas of Kudzu vine (Pueraria lobata). This perennial vine was introduced to the Southeast as a forage plant but has now become a serious pest. In both Georgia and Alabama it has laid claim to many old homesteads. Where it has been allowed to spread, this vine also kills forest trees. The vine forms a thick layer of leaves that apparently reflect more infrared than other

vegetation at this time of year; on simulated ERTS CIR it is the brightest red in the scene. In November these leaves will die and form a dense even layer of noninfrared reflectant material that should appear blue-gray on the simulated CIR. We hope to be able to follow this progression.

Digital Tape Analysis (Computer Processing):

1. Computer programs that include both supervised and unsupervised pattern recognition procedures are being modified from several developed in connection with NASA's Earth Resources Aircraft Program. One particularly promising procedure used unsupervised algorithms to cluster picture density elements, or sets of picture elements, into spectrally and/or spacially similar groups independent of land classes. The clustering algorithm was based upon the empirical multivariate distribution of red minus clear, blue minus clear, and green minus clear film densities. The clusters, or strata, were then classified according to land class attributes developed from training sets.

2. The application of these techniques gained through the aircraft program has not been applied to ERTS because neither bulk nor precision seven-track tapes have been available. Digital data tapes ordered on November 8 and delivered in late December were found imperfect. The bulk digital data tape was nine-track instead of seven, and the precision data tape was completely blank. The Data Users Center has been informed of these errors and the tapes reordered.

WORK PLANNED FOR NEXT REPORTING PERIOD:

Preparations and Equipment Developments:

1. Complete a vertical slide adjustment for the illuminator on the Bausch and Lomb Zoom Transfer Scope. This will enable a complete (9- x 9-inch) photograph to be viewed without moving the photograph.

2. Complete the mapping table for the ZTS with illuminator for working with two sets of color transparencies.

3. Complete the I^2S copy camera mount and calibration technique.

Aircraft and Ground Support:

There is no scheduled aircraft and ground support required during the next reporting period.

Film Data Analysis (Photo Interpretation):

1. The geometric fidelity of scene- and system-corrected data for ERTS scene 1084-15440 will be checked using control points carefully

plotted on a 1:1,000,000 scale transparent overlay. Distances between the UTM coordinate intersections and control points measured (1) on the 1:1,000,000 overlay and (2) on the ERTS image will be compared. From these results we will decide whether our data analysis plan is practical.

2. If the geometric quality of the scene is found good enough, one interpreter will examine all data analysis points found on ERTS scene 1084-15440. Using the training set, criteria will be developed to use in interpreting test set data.

3. New imagery from ERTS will be examined and evaluated as necessary.

4. All 800 data analysis points located on Mission 191 photography will be transferred to 1:60,000 CIR from ERTS support Mission 214. Each classification will be carefully reexamined and recorded. These data will be used to analyze results of interpretation of the ERTS imagery.

Digital Tape Analysis (Computer Processing):

If bulk and precision digital tapes are received, computer maps will be generated for two 6.4-kilometer-square areas (4-mile) using classification techniques developed for aircraft imagery.

SIGNIFICANT RESULTS: None

PUBLICATIONS: Aldrich, R. C., J. von Mosch, and W. J. Greentree. 1972. Projection-viewer for microscale aerial photography, U. S. Forest Service Research Note PSW-277. 4 p., illus.

RECOMMENDATIONS FOR CHANGES: None at present

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: 13 submitted

DATA REQUEST FORM CHANGES: None

TITLE: Inventory of Forest and Rangeland and Detection of Forest Stress

ERTS Proposal Number 226

Manitou Test Site (Rangeland Inventory) 226C

Coinvestigator: Richard S. Driscoll

GSFC Identification Number AG-014

Principal Investigator - Robert C. Heller

STATEMENT OF PROBLEMS:

1. No usable ERTS 1 imagery or CCT's which include data about the Manitou Test Site have been received. One batch of system-corrected MSS images (SYCI), Observation ID 1009-17075, was received but included only the eastern one-quarter of the 226C test site, and the photo frames were not synchronous for areal coverage. Imagery from channels 4 and 5 matched, from 6 and 7 matched, but channels 4, 5, and 6 or 4, 5, and 7 could not be matched. The NDPF Data Users Service was alerted to the problem, but we have since been advised the data will not be reprocessed to rectify the problem. This negates proposed analyses for that cycle of data.

2. A second set of MSS SYCI data from Cycle 5 has been received but included only about 1 percent of the 226C test site. The effective area imaged is in the northwest corner of the test site and did not include any of the validation, training, or testing points selected for interpretation procedures.

3. Scene-corrected images (SCCI) for Observation ID 1009-17075 have been ordered but not received. Also, two additional batches of SYCI data have been ordered from the U. S. Standard Catalog but have not been received.

4. Aircraft support data flown in September during Mission 211 by the NASA/MSC WB57F did not include the eastern one-third of the test site. Also, due to camera mount problems as reported in the Mission Report, and verified by inspection of the data, imagery from the RC8-4R (CIR) is of minimum value due to camera tilt. Although the total test site was covered by the combined Missions 205 and 211, there will be interpretation problems due to the seasonal changes in vegetation.

5. The aircraft support data flown during Mission 213 (NASA/MSC C130-B) in September did not include cloud-free coverage of the total planned area. This will partially limit analysis of the 24-channel MSS imagery.

ACCOMPLISHMENTS DURING THE REPORTING PERIOD:

1. All data from Mission 211 were received by November 6, 1972. Indexing is nearly complete, and selected interpretation training and testing points are being located and transferred from the Mission 205 photographs to those where coverage by the two missions is similar.

2. The topography of most of the area within the 226C test site that supports coniferous trees is very rough and broken. Preliminary stereoscopic interpretations of the largest scale (1:50,000) CIR photographs from both missions indicate that image differences between different kinds of coniferous tree types in these areas are very subtle and that discrimination between them is difficult. The use of associated evidences, such as slope, aspect, and elevation, will be required to provide discrimination differences among these coniferous forest types. In the few areas within the test site where topography is relatively gentle, image differences among coniferous forest types appear more discriminate. Variation in image characteristics of these forest types comparing June and September photography is minimal.

The deciduous forest type, aspen in our case, presents minimum visual stereoscopic interpretation problems provided photographs obtained prior to fall leaf discoloration are used. The apparent clonal variation of aspen in the Manitou area causes differential fall leaf coloration both in time and color such that photo or MSS discrimination after discoloration commences would be very confusing.

3. Interpretation of the nonforest vegetation classes is much more time dependent than the forest vegetation classes. Changes in both phenology and man activities caused considerable variation in image characteristics during the summer growing season. For example, some of the wet meadow areas are cut for hay in the late summer and fall, and grazing by livestock of some of the areas during the summer changes the energy relationships of these vegetation classes. Therefore, remote classification for these vegetation types for minimum error from either aerial photographs or MSS data would be required prior to man activities to avoid omission and commission errors. Interpretation from the Mission 205 (June) photographs was better suited for this purpose than the Mission 211 (September) photographs. The image characteristics of the nonforest vegetation classes were sufficiently discrete in all photo scales that the classes were identifiable. However, small photo scale and limited areal extent of some portions of the vegetation classes require subsampling with larger scale photos to determine such parameters of the areal extent of the vegetation classes.

4. All Mission 213 data were received by November 7, 1972, and have been reviewed, indexed, and logged into our file system. The Mission was flown initially on September 13, 1972, but cloud shadows diluted usefulness of the data. The Mission was reflown on September 14, 1972.

Hotspotting occurred in the aerial photographs and after consultation with the NASA/MSC Data Management Section, additional photographs were requested to improve image quality. These data have not yet been received. Also, processing of the 24-channel MSS data obtained at the same time has not been requested until we have opportunity to examine the rectified photographs.

5. The transparent overlays identifying the location of training and test sets for the vegetation classes to be interpreted from ERTS 1 imagery were completed.

ACCOMPLISHMENTS DURING THE TOTAL CONTRACT PERIOD:

1. Natural vegetation within the test site area has been classified into seven forest classes, two scrub classes, and six grassland or meadow classes. These include:

FOREST	SCRUB	GRASSLAND OR MEADOW
Ponderosa pine	Willow	Shortgrass
Spruce-fir	Mountain mahogany	Mountain bunchgrass
Douglas-fir		Wet meadow
Lodgepole pine		Dry meadow
Whitebark/Limber/ Bristlecone pine		Ephemeral meadow
		Seeded grassland
Pinyon-juniper		
Aspen		

In accordance with the general objectives of our experiment, "To test the hypothesis that ERTS multispectral imagery will permit identification of forest and rangeland resources", sampling points were selected within each of the forest classes using U. S. Forest Service timber type maps. Each point represented a 300- or 500-meter training or testing data cell, and they have all been keyed to the Universal Transverse Mercator (UTM) map coordinate system to facilitate location and description in ERTS imagery. A 10 percent sample of all points selected was ground-located to validate the preclassification. At the same time, data about plant species composition and physical site factors at each validation point were secured to assist in interpretation of both satellite and aircraft imagery and explain reasons for variance. In total, 556 500-meter and 883 300-meter data cells have been keyed for forest vegetation classification.

Vegetation maps or aerial photos were not available of those areas where the scrub and grassland or meadow type vegetation occurs. Therefore, the areas were flown for CIR aerial photography on June 7-9, 1972, with our Forest Service Aero Commander. Since we could not map in detail this portion (approximately 40%) of the total area, selected locations by vegetation class were identified, keyed to UTM, and transferred to base topographic maps for later location in ERTS imagery. These point samples will be used to train either the computer or human interpreters for classification of the total nonforest area. The results will then need to be ground verified.

2. Intensive ground truth was obtained at Manitou proper during the first three weeks in August to correlate with the first ERTS data pass. Information obtained included multispectral radiance of individual plant species and species mixtures using an ISCO radiometer; ground cover, including plant foliar cover, amount of litter, and bare soil surface; and standing crop biomass of four different grassland classes. These data are currently being analyzed to relate the ground parameters to each other. At essentially the same time this ground truth was obtained, multispectral photographs were secured at four scales of the same areas using the Forest Service Aero Commander. Optical image density of the areas measured by a scanning microdensitometer will be assessed against the ground truth parameters through correlation and regression. It was planned to use these data as the base for quantifying the ERTS imagery of the area through multiple sampling.

3. Three NASA aircraft data-gathering missions were completed over the test site. Missions 205 (June) and 211 (September) were multispectral photographic done with the WB57F. All data have been received, indexed, and logged into the filing system. Sample points for plant community classification are being transferred to the photos for interpretation training and testing. In general, data received are good except test site coverage was not complete for either mission. Also, camera problems previously mentioned negate use of one film type from Mission 211.

Data from Mission 213 (C130-B) have been received and logged. Problems with these data have been previously described. MSS data analysis from this mission has not progressed but will be done after correlating DAS time allotments with data from the Black Hills and Atlanta sites.

WORK PLANNED FOR NEXT REPORTING PERIOD:

1. Complete data point transfer from base maps to aerial photographs and proceed with interpretation for plant community classification.

2. Initiate analysis of plant community characteristics by microdensitometry using the Aero Commander photography and include testing relationships with this result with spectral radiances obtained at ground level.

3. Begin detailed analysis of ERTS data as it becomes available.

SIGNIFICANT RESULTS: None

PUBLICATIONS: None

RECOMMENDATIONS FOR CHANGES: Speed up ERTS data flow to us.

STANDING ORDER FORM CHANGES: None

ERTS IMAGE DESCRIPTOR FORMS: None due to lack of ERTS imagery.

DATA REQUEST FORM CHANGES: Two sets of SYCI ordered via telephone: Observation I.D. 1027-17075 and 1028-17135.